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ABSTRACT

The effects of stress on state anxiety and heart rate of male high school subjects were investigated. Two psychomotor tasks were used. In the stress condition, subjects received negative feedback about performance; the subjects in the nonstress condition were given rest intervals. Subjects in both conditions showed differing regression lines. The nonstress group maintained the same state anxiety level across the tasks, with increased heart rate occurring as a result of the motor tasks. The stress group increased in state anxiety and heart rate measures. The two groups were significantly different (at the .01 level) on all within-task measures and the stress group performed better on the two motor skill tasks. (Author)

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Leigh F. Kieffer and Robert D. Tennyson

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Leigh F. Kieffer
and
Robert D. Tennyson

Florida State University

ABSTRACT

The effects of stress on state anxiety and on heart rate of male high school Ss were investigated. Two psychomotor tasks were used. In the stress condition, Ss received negative feedback about performance; the Ss in the nonstress condition were given rest intervals. Ss in the two conditions showed similar pretask ($p > .05$) A-State and heart rate measures. However, during the tasks the groups showed differing regression lines. The nonstress group maintained the same A-State level across the tasks with increased heart rate occurring as a result of the motor task. The stress group increased in A-State and heart rate measures. The two groups were significantly different ($p < .01$) in all within-task measures. The stress group performed better on the two motor skill tasks.

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Florida State University

Physiological factors produce adjustments in heart rate to meet the requirements of the behavioral situation. The internal homeostasis of the organism reflects the demands of changing metabolic activity to the changing environment. Initial rises in heart rate are frequently demonstrated prior to activity as a result of reflex activity in the cortex caused by anxiety, excitement, or anticipation of new and different experiences (Suggs & Splinter, 1966). For example, Dill (1959) found that significant increases in heart rate were experienced in teenage males prior to testing in a laboratory situation.

Several studies have investigated the effects of anxiety proneness of Ss learning to perform motor tasks (Castaneda & Lipsitt, 1971; Ryan, 1962; Carron, 1968). Physiologists have studied the metabolic or chemical changes within the body resulting from stressful conditions (Datta & Ramanathan, 1969; Franks & Cureton, 1968). An appropriate direction for research on anxiety would be the simultaneous measurement of psychological and physiological variables during induced states of stress using multivariate analysis procedures. One experimental method of inducing stress is to present consistently negative knowledge of results of performance on psychomotor tasks.

Hypothesis. The present study proposed to extend cognitive studies concerned with trait and state anxiety measures into the psychomotor domain (Tennyson & Boutwell, 1973; O'Neil, 1972). It was hypothesized that induced stress, through negative feedback, would cause increases in state anxiety and heart rate during psychomotor task performances. The purpose was to obtain concurrent measures of anxiety using self-report instrument (measuring both trait and state anxiousness) and a physiological measure of heart rate.

Method

Subjects. Twenty-three eleventh grade males (ages 15-16) were randomly selected from Florida State University's Research and Developmental Laboratory School. The school's student body is representative of the state's population norms for cognitive, ethnic, and racial characteristics. Ss were required to participate in the study as part of their physical education class activities. Three Ss took part in the preexperimental tryouts of the two treatment conditions. One S was dropped from the data analysis due to a failure in obtaining a consistent measure of heart rate during Task B.

Psychomotor tasks. Two psychomotor tasks were selected as irrelevant treatments through which stimulation of anxiety states could be planned and observed. The learning of the tasks was not for the purpose of improving skill, per se; but rather to require Ss to perform a relatively simple task where the conditions for stimuli could produce a differential level of anxiety and could be expedited effectively while the S was still performing. The anxiety level was manipulated by means of concurrent, controverted feedback on

task performance. The results of performance given to each S in the experimental group was consistently negative regardless of actual performance. Ss in the control group were told that they were assisting in the testing of a new piece of reaction time/movement time apparatus and received no feedback regarding their performance.

The motor tasks included an "easy" task of reaction time (RT) in response to a visual stimulus (Task A), and a "hard" task of reaction time and movement time (RT-MT) using the same visual stimulus (Task B). Tasks were designated as easy or hard with respect to the amount of muscular involvement required. These tasks were selected because they could be measured within a restricted environment and administered over a short time duration. Lapse of time between trial or task sessions was eliminated, for testing occurred during a 45-minute period for each S.

Task A (RT) consisted of Ss placing their right forearm, with palm down, flat on a specified portion of the testing panel in such a manner that their index finger completely covered a photo sensitive cell. This obstructed a beam of light focused on the cell which was connected to a timer recording in milliseconds the time lapse between appearance of the proper light stimulus and the removal of S's finger from the cell. Every time a blue light appeared, the S knew that within one to four seconds a white light would appear to which he was to respond in the appropriate manner. The S was given eight trials per period. Following each period a red light appeared at which time Ss were either given consistently poor evaluations (i.e., negative feedback) of their performance or a rest break. The task consisted of four periods.

Task B used the initial procedure of Task A except that upon being presented with the white stimulus light, Ss were instructed to move their entire arm from position A, across the panel, and continuing through a photo sensitive cell marked B. Directions emphasized that this movement should be done very quickly with a sweeping motion.

Apparatus. All control systems were located in a separate room. The logic for photocell amplifiers, visual stimuli, and timer recorders was programmed into a BRS Foringer Digilab DLC-001 Solid State Logic. Internal sequencing of the rationale for generation of all visual stimuli was used to insure randomization of presentation. Observation of heart rate was accomplished by placing an electrode on the S's left arm in the area of the brachial artery. The electrode was held in place with a cloth cuff and electrode strap. The Easterline Angus Event Recorder, model A 620X, monitored heart rate with a paper speed of six inches per minute. A white noise generator, model 24-21B, with microphone and two-way output communication, was used to mute outside noise in the testing room.

Anxiety measures. The Spielberger, Gorsuch, and Lushene (1970) Trait-State Anxiety Inventory (STAI) was used to measure both aspects of anxiousness of Ss. The A-State (Form X-1) required the Ss to indicate how they felt "at that moment." The A-Trait (Form X-2) was used to measure how Ss "generally felt."

Experimental design. The multiple treatment design (Campbell & Stanley, 1963) established pretask baseline measures for state anxiety and heart rate. This design allowed for the multivariate analysis of within-task changes which resulted from the presentation of various

treatment conditions. The two-treatment design controlled for the effect of heart rate increases occurring during the psychomotor tasks. The first treatment group received negative feedback on performance after each of four periods per task, which was hypothesized to produce stress with an accompanying increase in heart rate. The control group was given a rest interval following each period; it was assumed that heart rate increases would occur only from the physical activity required from the tasks. Along with multiple measures of heart rate and task performance the STAI A-State Scale scores were taken; one during the pretask period and one at the conclusion of each of the task periods.

Procedure for pretask period. Ss were assigned to individual testing times and treatments which had been randomly generated prior to the experiment. At the beginning of the pretask period the electrode was placed on the upper left arm of the S; following this the purpose and directions for using the Self-Evaluation Questionnaires (STAI A-Trait and A-State Scales) were read aloud to each S. Ss in the stress group were additionally told that their scores were being recorded on a computer which had been programed to evaluate their performance as they proceeded through the program. The Ss were directed to answer the STAI A-Trait Scale and then the first in a series of three A-State self-report forms.

After the first pretask A-State form was finished, the experimenter briefly explained when the subsequent forms were to be answered, and remained in the testing room while the apparatus procedures were explained and practice trials completed.

Procedure for within-task period. After each period of the tasks negative feedback on performance was given to the stress group regardless of their actual scores. It was necessary to generate evaluative feedback responses for each task centered upon the inadequacy of the S's performance, speed, speed and performance, and reaction time and/or movement time. This negative feedback was given immediately at the conclusion of each period. The nonstress group was given an equal-time interval of rest following each period of the two tasks. The first two periods in each task were warm-up periods consisting of eight trials each. During this period Ss were trained by the same method and with the same feedback or rest intervals that they experienced during periods three and four. At the conclusion of each task the Ss were directed to respond on the STAI A-State Scale according to how they felt during the task.

Results

Dependent variables. The data were organized into three major sections according to the experimental format shown in Table 1. In the first section baseline measures of anxiety trait, anxiety state, and mean heart rate were gathered. Measures within each subsequent section included additional variables of performance on the task. The reaction time and movement time tasks were measured in milliseconds.

Ten dependent variables were analyzed over all subjects in both groups using a multivariate statistical design. These were the STAI A-Trait and A-State Scale scores(4), the heart rates(3), and the reaction time and movement time measures(3). The multivariate analysis of variance was selected because of the interdependence of the variables, that is, the

treatment affected state anxiety level, anxiety affected heart rate, with both affecting task performance. The data analysis on the ten variables resulted in a significant difference between the stress and nonstress groups ($U > .11$, $df = 10,1,17$, $p > .05$) (Table 1). To determine which variables were statistically different, univariate tests were conducted on each variable plus selected multivariate interaction tests.

Pretask variables. Results of the univariate tests on the two anxiety measures and heart rate showed that the two groups did not significantly differ on the pretask variables ($p > .05$) (Table 1). Since no standardized norms or other comparable data existed on heart rate using similar Ss or experimental situations, the pretask means were used as baselines to interpret heart rate changes that occurred in the subsequent periods of the two treatments. The STAI A-State Scale scores can be compared to previously acquired data. Two past studies (Tennyson & Boutwell, 1973; Tennyson & Woolley, 1971) had A-State means of 36.2 and 36.6, which are slightly lower to the means of 43.3 (stress group) and 38.5 (nonstress group). On the 20-point scale, minimum of 20 (low anxiety) and maximum of 80 (high anxiety), it was assumed that the two anxiety mean measures showed an average trait and state anxiety level for the two groups. Thus, prior to the introduction of the stress or nonstress condition the Ss had comparable self-reported anxiety scores and heart rates.

STAI A-State. The measure of S state anxiety was a dependent function of the type of stress or nonstress condition. A second measure of A-State was taken immediately after Task A, with Ss reporting on how they felt during the task. The stress group had a mean of 50.4, an increase of 7 points over the pretask A-State mean, while the nonstress

TABLE 1

Means and Standard Deviations of the Dependent Variables in the Stress and Nonstress Conditions

Groups	Pretask**			Task A			Task B			
	A-T*	$A\text{-}S_1$*	HR_1*	RT_1*	$A\text{-}S_2$	HR_2	RT_2	MT*	$A\text{-}S_3$	HR_3
Stress (N=10)										
M	38.4	43.3	86.4	.28	50.4	99.0	.30	.15	51.6	113.5
SD	7.5	3.1	8.5	.01	9.6	7.4	.02	.02	7.7	5.2
Nonstress (N=19)										
M	35.8	38.5	80.1	.33	39.3	80.2	.36	.25	40.4	101.5
SD	7.5	7.0	8.7	.02	5.1	6.7	.03	.06	5.0	5.8

* A-T = Trait Anxiety; A-S = State Anxiety; HR = Heart Rate; RT = Reaction Time; MT = Movement Time.

** Pretask parameters indicated baseline measures for the purpose of this study.

group's second mean was 39.3 (Table 1). Using an univariate test, the two groups were significantly different on the STAI A-State Scale scores ($F = 9.38$, $df = 1, 17$; $p > .05$). The STAI A-State Scale data indicated that the nonstress Ss remained constant in their self-report of feelings during the tasks; however, the stress Ss responded with an increase in anxiety after receiving negative feedback on their performance.

Heart rate. Ss had their heart rates monitored throughout the experiment. Heart rates were calculated for each period of the treatment, that is, during the pretask period, and during the four periods in each of the two tasks. Periods one and two were considered practice conditions for the psychomotor tasks, while periods three and four were averaged per task as the dependent variables, giving each S three heart rate measures. Pretask heart rates were nonsignificantly different between the two groups, even though the mean of 86.4 for the stress group was higher than the nonstress group's mean of 80.1 ($p > .05$) (Table 1). During Task A the average heart rate of the stress group increased to a mean of 99.0. It was anticipated that the physical movement of the reaction time task would increase the heart rate; however, the nonstress group had the same reading for Task A as it did during the pretask period. The univariate test on the Task A heart rates showed a significant difference between the two groups ($F = 32.88$, $df = 1,17$; $p > .05$).

The movement demands for Task B did affect the heart rates for both groups. The stress group had an average increase of 14.5 beats per minute for a mean of 113.5. The nonstress group heart rate went from a Task A mean of 80.2 to 101.5 for Task B, a 21.3 heart rate increase. The

stress group maintained a significantly higher heart rate (F = 22.06, df = 1,17; p >.05), but the gap between the groups' heart rates decreased during Task B.

Reaction and movement time variables. A secondary concern in this study was the performance of the Ss on the psychomotor tasks. Ss were given eight trials per period, with four periods per task. As with the heart rate data analysis, the first two periods per task were considered practice, and for analysis purposes, periods three and four ware averaged for each task. The Task A reaction time means (Table 1), measured in milliseconds, showed that the stress group (M = .28 msec) was significantly faster than the nonstress group (M = .33 msec.) (F = 25.90; df = 1,17; p >.05). A similar performance difference resulted in Task B, with the stress group having significantly better performance times on both conditions of reaction time (stress group M = 30 msec.; nonstress group M = .36 msec.)(F = 18.00; df = 1,17; p >.05) and movement time (stress group M = .15 msec.; nonstress group M = .25 msec.) (F = 18.18; df = 1,17; p >.05) than the nonstress group. Because of the different movement requirements for Task B, the reaction times in both groups are two to three milliseconds increments higher than Task A.

Interactions. Interactions reported were those selected to be interpretable in terms of the hypotheses investigated. The interactions using the pretask STAI A-State Scale and heart rates with the Task A A-State and heart rate and the Task A reaction time were non-significant (p >.05). The interaction between the groups' A-State and heart rate measures was likewise nonsignificant (p >.05). This indicated that the regression lines of the two groups on the above measures did

not change significantly from the pretask to Task A. However, the regression lines showed a significant interaction when analyzing the pretask A-State and heart rate measures with the equivalent Task B measures ($U > .63$); the slopes for the stress and nonstress groups increased at different levels. An interaction between the pretask A-State and heart rate measures with the Task B reaction and movement times resulted in ordinal slopes ($U > .76$). A disordinal interaction occurred between the Task B measures of A-State and heart rate with reaction and movement times ($U > .30$). The stress group with a reported A-State mean of 51.6 and heart rate of 113.5 beats/min. had a reaction time mean of .30 msec. and a movement time mean of .15 msec, while the nonstress group, with an A-State mean of 40.4 and a heart rate of 101.5 beats/min., had a mean task time of .36 msec. and .25 msec., respectively.

Correlations. The pretask A-Trait scores and the three A-State measure correlations demonstrated the inconsistency of the Ss self-reporting in the two treatment conditions ($df = 17$, $p > .05$). The stress group correlations were .29 ($A\text{-}S_1$), .22 ($A\text{-}S_2$), and .15 ($A\text{-}S_3$), while the nonstress group had the following, .60 ($A\text{-}S_1$), .70 ($A\text{-}S_2$), and .75 ($A\text{-}S_3$). However, the pretask A-State correlated with the stress group at .73 ($A\text{-}S_2$) and .66 ($A\text{-}S_3$), but with the nonstress group at .47 and .51, respectively. Heart rate correlations were also diverse in that the pretask heart rates for the stress Ss were consistent at .55 (HR_2) and .47 (HR_3), with the nonstress Ss showing an opposite trend at .66 (HR_2) and -.18 (HR_3). Within-task correlations also showed contradictory results for the two groups. The only correlation in which the groups demonstrated similarity was in the two A-State measures (stress group $r = .97$; and nonstress group $r = .94$). Performance correlations on the reaction time scores in Tasks A

and B were comparable in that the stress group had an r = .65 and the nonstress group r = .55. One final correlation of importance was between the Task B performance scores (RT_2 and MT), where stress Ss showed a correlation of .75, while the nonstress Ss showed an r of .30.

Discussion

The purpose of this study was to investigate the concurrent correlation of self-report anxiety with heart rate measures on two motor tasks. Results of the pretask variables of STAI A-Trait and A-State demonstrated that both groups were similar for these measures. However, A-Trait was not shown to be a good predictor of anxiety within motor tasks for the stress group. Since this group was introduced to a stressful environment from the beginning of the experiment, and as predictive reliability measures between A-Trait and A-State usually yield high correlations in nonstress situations, these differences were hypothesized. The nonstress group's A-Trait and A-State correlations were more representative of past findings. The impending threat of evaluative feedback about performance led to an initial increase in the activation of general anxiety potential. These results were also paralleled by the physiological measures which demonstrated that Ss in the two groups did respond differently to the two treatment conditions.

Performance on the two motor tasks was also represented in the fluctuations in A-State and heart rate for both groups. Of particular importance were the scores exhibited by the stress group. They were consistently better on both tasks than the nonstress group. The reactive effect of constant negative feedback contributed to a performance difference that was not noted in the nonstress treatment group.

The transitory nature of anxiety would indicate that how individuals perceive the circumstances should be considered. As Spielberger (1971) has indicated, stress which produces threats to self-esteem, that is, negative evaluation of performance, should be considered as another index of the fitness of a situation in which an individual might learn or perform a given task. Therefore, the appropriateness of research on anxiety and motor behavior would seem to be reliant upon assessment of the strengths of competing and correct responses. Obtaining data in these situational anxiety approaches ameliorates optimization of potential learning situations and would offer a more sensitive tool for individualizing strategies and evaluating responses.

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